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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAM OF THE

PITTSBURGH MEETING

AT

THE UNIVERSITY OF PITTSBURGH

THE CARNEGIE INSTITUTE OF TECHNOLOGY

AND

THE MELLON INSTITUTE OF INDUSTRIAL RESEARCH

Pittsburgh, Pennsylvania

JUNE 20, 21 AND 22, 1940

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The American Physical Society

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JUNE 6, 1940 Vol. 15, No. 4

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

PITTSBURGH MEETING, JUNE 20, 21 AND 22, 1940

(Eastern Daylight Saving Time)

THE 236th regular meeting of the American Physical Society will be held in Pittsburgh, Pennsylvania, on Thursday, Friday and Saturday, June 20, 21 and 22, 1940. The scientific sessions will be held at the University of Pittsburgh, the Carnegie Institute of Technology, and the Mellon Institute for Industrial Research. The first session will be at 9:30 o'clock, Thursday morning, June 20, Daylight Saving Time.

Hotel Accommodations. Headquarters will be at the Webster Hall Hotel (directly across from the University of Pittsburgh Cathedral of Learning and the Mellon Institute for Industrial Research).

Rates: single rooms without bath, $2.00; double rooms without bath, $3.00; single rooms with bath from $2.50; double rooms with bath from $4.00. Reservations should be made as far in advance as possible directly with the hotel.

The Hotel Schenley is also conveniently located to the meetings.

Registration. Registration ($1.00 per family) will open in the lobby of the Webster Hall Hotel at 8:30 A.M. on Thursday.

Visits to Industrial Plants. On Thursday afternoon, opportunity will be provided to take one of two trips:

(**A**) Aluminum Company Works and Research Laboratories. Laboratory tests on aluminum alloys; stamping and spinning of kitchen ware.

(**B**) Jones and Laughlin strip mill and blast furnaces. Continuous rolling of sheet steel, "pilot" mill, blast furnaces, open hearth furnaces.

On Friday afternoon, opportunity will be provided to take one of two trips:

(**C**) Westinghouse Research Laboratories. Large pressure insulated electrostatic generator and other items of industrial research program.

(**D**) Westinghouse East Pittsburgh Works. Manufacture of large generators, circuit breakers, etc.

(**E**) On Saturday afternoon there will be an opportunity to inspect the Gulf Research Laboratories in the early part of the afternoon before the picnic, which will be held on the grounds of the Gulf Laboratories in the late afternoon.

Please use the blank on Page 7 to indicate which of the trips you desire to take.

Luncheon. Luncheon may be had at the Webster Hall Coffee Shop, Schenley Coffee Shop, King Edward Dining Room, The Culinaire, Ruskin Apartments, and other restaurants in the neighborhood.

Dinner. There will be an informal dinner at the Webster Hall Hotel at 7:00 P.M. Friday. Tickets at $1.65 each may be purchased at the registration desk at the Webster Hall Hotel until Friday at 12 noon. The dinner will be followed by light entertainment.

Please use the blank on Page 7 for advance registration for the dinner.

Symposium. On Saturday at 9:30 A.M., there will be a symposium of invited papers sponsored by the Committee on Applied Physics of the American Physical Society. Dr. Frederick Seitz of the University of Pennsylvania will speak on

"The Theory of Internal Strains in Solids"; Dr. Paul D. Foote of the Gulf Research and Development Company on "Gasoline"; and Dr. R. H. Kent of the Aberdeen Proving Ground on "Physical and Chemical Characteristics of Explosives and Their Military Applications." This symposium will be held in the auditorium of the Mellon Institute for Industrial Research (use Bellefield Avenue entrance).

Entertainment. On Thursday afternoon from 4 to 6 the Society will be entertained at tea in the Commons Room of the Cathedral of Learning as guests of the University of Pittsburgh. On Thursday evening a broadcast program, "Musical Americana," presented by the Westinghouse Electric and Manufacturing Company, may be attended in the Syria Mosque on Bigelow Boulevard, a short walk from the hotel. Tickets, which will be free, should be obtained on registration at the registration desk. It is requested that members of the Society be seated before 7:30, since seats are not reserved and the hall seating 3800 has been filled every week. Doors are closed at 7:50 P.M.

On Saturday afternoon, following inspection of the Gulf Research Laboratories, there will be a picnic on the grounds of the laboratories. It is necessary that tickets be obtained, at 75¢ each at the registration desk, before Friday at 12 noon. Tennis, volley ball, mush ball, and horseshoes will be played.

Swimming at the Webster Hall Hotel is free to guests of the hotel. For information about golf and tennis facilities please inquire at the registration desk.

Ladies' Program. The following plans have been made for the ladies attending the meeting:

Thursday: 10 to 12 noon—Visit to Carnegie Art Gallery and Museum.

2 P.M.—Tour of University of Pittsburgh nationality rooms, Heinz Chapel, and Foster Memorial.

4 to 6 P.M.—Tea in Commons Rooms of Cathedral of Learning.

7:30 P.M.—"Musical Americana" Broadcast in Syria Mosque.

Friday: 10 A.M.—Sight-seeing tour of Pittsburgh, including complimentary luncheon at and inspection of the H. J. Heinz Company.

4 P.M.—Tea at Union of Carnegie Institute of Technology.

7 P.M.—Informal dinner at the Webster Hall Hotel.

Saturday: 10 A.M.—Inspection of Phipps Conservatory and Garden Center.

Afternoon—Picnic at Gulf Research Laboratories.

Railroad Rates. Members should consult with their local ticket agents before purchasing tickets.

Conference on Applied Nuclear Physics. Members of the Society will be interested in the announcement of the American Institute of Physics that a Conference on Applied Nuclear Physics will be held in cooperation with the Massachusetts Institute of Technology during the week of October 28–November 2. The Conference will consist of sessions of short invited papers with ample time for discussion. Provision is also made for a few ten-minute contributed papers. Five evening sessions will be open to the general public. The regular sessions are open to anyone who can actively participate in or profit by the Conference. Registration before October 1 is necessary.

In addition to general sessions on the production and measurement of radioactive and stable isotopes and of penetrating radiations, there will be a session on the protection of workers. There will also be special sessions on applications in the fields of biology, chemistry, radiology, metallurgy and geology. Included among the topics covered will be tracer techniques in various fields, standards in radioactivity measurements, geologic age, geophysical applications, radiography of metals and metal diffusion, radium therapy, dosage measurements, synthesis of organic substances and other aspects of the use of radioactive materials and of neutrons and other nuclear radiations. Further information may be obtained from the American Institute of Physics.

General Rules Relating to Papers

Only those titles of papers shall be listed on the preliminary program of a meeting of the Society for which abstracts ready for publication are in the hands of the Secretary.

On December 28, 1936, the Society voted that:

No papers may be accepted for presentation at any meeting of the Society subsequent to the closing date stated in the printed call for that meeting.

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program. (A paper presented by two or more authors is assigned to the first named author.)

All supplementary papers will be grouped according to subject matter and will be called for at their appropriate sessions only, these sessions to be designated on the program. The presiding officer may assign a reduced time to these papers or may in his discretion call for them to be read by title only.

Except by special vote of the Society, the maximum allowance of time for the presentation of a paper shall be ten minutes. The presiding officer shall enforce this rule.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts will be published in an early number of the *Physical Review*. Authors should send corrections to the Publications Manager, The American Institute of Physics Incorporated, 175 Fifth Avenue, New York, N. Y.

Other meetings for the current season are as follows:

235. June 18–21, 1940. Seattle, Washington. Pacific Coast Meeting.

237. November 22–23, 1940. Chicago, Illinois.

238. December, 1940. Pasadena, California. Pacific Coast Meeting.

239. December 26–28, 1940. Annual Meeting. Philadelphia, Pennsylvania.

240. February 21–22, 1941. Cambridge, Massachusetts.

W. L. SEVERINGHAUS, *Secretary*
Columbia University, New York, N. Y.

June 6, 1940.

CALENDAR

Eastern Daylight Saving Time

For the special program arranged for the ladies attending the meeting, see page 4.

Thursday morning, June 20

8:30 o'clock: Registration starts at the *Webster Hall Hotel.*

Cathedral of Learning, University of Pittsburgh

9:30 o'clock: Room 132: Papers Nos. 1–13. See pages 9–12.

9:30 o'clock: Room 324: Papers Nos. 14–22. See pages 12–14.

Thursday afternoon, June 20—Trips to either:

(A) Aluminum Company Works and Research Laboratories; or

(B) Jones and Laughlin strip mill and blast furnaces.

Thursday evening, June 20—*Syria Mosque on Bigelow Boulevard*

7:30 o'clock: "Musical Americana" broadcast.

Friday morning, June 21

9:00 o'clock: Meeting of the Council in Chinese Room in the Cathedral of Learning.

Engineering Hall, Carnegie Institute of Technology

9:30 o'clock: Room 209: Papers Nos. 23–33. See pages 14–16.

9:30 o'clock: Room 218: Papers Nos. 34–43. See pages 16–18.

9:30 o'clock: Room 60: Papers Nos. 44–54. See pages 18–21.

Friday afternoon, June 21—Trips to either:

(C) Westinghouse Research Laboratories; or

(D) Westinghouse East Pittsburgh Works.

Friday evening, June 21—*Webster Hall Hotel*

7:00 o'clock: Informal dinner.

Saturday morning, June 22—*Mellon Institute for Industrial Research*

9:30 o'clock: Auditorium: Symposium of invited papers on applied physics: Speakers—Dr. Frederick Seitz, Dr. Paul D. Foote, and Dr. R. H. Kent.

Saturday afternoon, June 22—*Gulf Research Laboratories*

Inspection of Laboratories and picnic.

If you plan to attend the meeting please fill out and mail this advance registration card promptly. It will greatly facilitate the efforts of the local committee in making arrangements.

ADVANCE REGISTRATION CARD

American Physical Society

PITTSBURGH MEETING, JUNE 20–22, 1940

Please fill out at once and send to Department of Physics, University of Pittsburgh, Pittsburgh, Pa.

Write directly to hotel for your room reservations.

Name..... (Last name / First name / Initials)

I plan to go to Pittsburgh by { automobile..... / train ..... }

I plan to take the following trips:

Thursday { (A) Aluminum Company ..... / (B) Jones & Laughlin Steel Mill ..... }

Friday { (C) Westinghouse Research Laboratories ..... / (D) Westinghouse East Pittsburgh Works..... }

Saturday (E) Gulf Research Laboratories .....

My wife plans to take sight-seeing tour on Friday .....

Details about time of starting and transportation will be available at the registration desk.

Please reserve.....tickets for "Musical Americana" Broadcast on Thursday.

Please reserve.....tickets for dinner on Friday at $1.65.

Please reserve.....tickets for picnic on Saturday at 75¢.

PROGRAM

THURSDAY MORNING AT 9:30 O'CLOCK

Cathedral of Learning, University of Pittsburgh

Room 132

1. Application of a Cloud Chamber to the Detection of Charged Particle Groups. H. L. SCHULTZ, W. L. DAVIDSON, JR., AND L. H. OTT, *Yale University.*—The ranges of charged particles resulting from nuclear transmutations have been studied almost exclusively with the use of proportional counters and ionization chambers. Such methods suffer three definite limitations, particularly when a cyclotron is used to produce a high energy beam of bombarding particles. In the first place, the presence of a large neutron background interferes with the detection of weak groups. Secondly, absolute yields are difficult to obtain since a high counting level is necessary in order to discriminate against β-radiation. Finally, the finite depth of counting volume impairs the resolution of groups. All of these limitations may be overcome by allowing the particles to register in an expansion chamber. The fundamental technique has been described by Bower and Burcham. We have adapted a diaphragm type of expansion chamber for use in conjunction with the cyclotron in carrying out studies of this nature. Two argon flash tubes serve as an intense source of illumination over very short periods of time. Nonstereoscopic photographs are taken with the aid of an automatic camera. The particles are allowed to pass down an evacuated tube at right angles to the incident beam and enter the cloud chamber 40 cm from the target. Preliminary experiments have verified the presence of the strong 28-cm proton group from boron bombarded by 3.1 Mev deuterons as reported earlier by Pollard, Davidson, and Schultz. Evidence for an excited state in C^{13} has also been found. The reaction $Al^{27}(d,p)Al^{28}$ has been studied with an aluminum target of 0.15-cm air equivalent thickness. The groups found by McMillan and Lawrence also appear in the present work. In addition there is evidence for other groups. A detailed investigation of *d-p* reactions is now being carried out.

2. Longitudinal Extraction of Ions from Low Pressure Constricted Arc Discharge in H_2 and in BF_3. HOFF LU AND RALPH H. SCHUMAN, *University of Minnesota.*—We have attempted to extract ions efficiently from a low pressure arc confined in a cylindrical steel constriction. Ions are drawn out along the arc axis through a tungsten loop filament by a 1-mm hole probe at 2 kilovolts. A 3-mm shielding hole at arc potential in front of the probe produces a converging field which further concentrates the ions toward the center of the probe. By making the loop area of the filament smaller than the constrictional cross section, an arc of 2.5 cm length to the anode can be struck by the self-striking auxiliary arc to the constriction. A focusing cylinder accelerates the ions into a parallel beam which terminates at a collector biased to 50 volts to retain secondary electrons. The ion yield increases rapidly with decreasing pressure except near the threshold pressure where the arc goes off. Results are given below. A preliminary test with a second source improved in geometry and choice of materials indicates an increase in ion output by a factor of ten.

Arc in	H_2	BF_3
Lower pressure limit, mm of Hg	4×10^{-2}	2×10^{-2}
Satisfactory operating state:		
Pressure, mm of Hg	6×10^{-2}	3×10^{-2}
Arc current, milliamperes	125	150
Arc drop, volts	80	70
Steady ion beam current, microamperes	90	120

3. Some Experiments on the Irradiation of Deuterium, Beryllium, and Indium Nuclei by X-Rays. D. L. NORTHRUP, C. M. VAN ATTA, R. J. VAN DE GRAAFF AND L. C. VAN ATTA, *Massachusetts Institute of Technology.*—Yield curves will be shown for the disintegration of deuterium and beryllium[1] with continuous x-rays produced by the impact of a homogeneous beam of electrons on a gold target. The high voltage electrostatic generator and accelerating tube employed have been described.[2] The yield curves were observed as a function of the accelerating voltage applied to the electrons and extend from below threshold to a voltage of 2.65 Mev. The threshold voltages for both deuterium and beryllium, as measured on a generating voltmeter, were found to be in good agreement with values obtained in other laboratories. In both cases the neutrons from the disintegrations were detected by measurement of the radioactivity they produced in silver. Preliminary observations are in progress on the angular distribution of the neutrons from the deuterium disintegration. Excitation with x-rays of the 4.1-hour period in indium[3] was observed by surrounding a thin walled Geiger-Müller counter with the irradiated indium as well as by irradiation of counters constructed with indium cathodes. The latter counters showed, in addition to the 4.1-hour exponential decay, a more rapid exponential decay in counting rate consistently reproducible with a given counter, but shown by further experiments to be non-nuclear in origin.

[1] G. B. Collins, B. Waldman, and E. Guth, Phys. Rev. **56**, 876 (1939).
[2] Phys. Rev. **57**, 563A (1940).
[3] B. Pontecorvo and A. Lazard, Comptes rendus **208**, 99 (1939). G. B. Collins, B. Waldman, E. M. Stubblefield, and M. Goldhaber, Phys. Rev. **55**, 507L (1939).

4. Protons from Deuteron Bombardment of Separated Chlorine Isotopes. E. F. SHRADER AND E. POLLARD, *Yale University.*—Deuteron bombardment of chlorine yields three energy groups of protons. To determine the assign-

ments of the groups a target of AgCl enriched in the heavy isotope has been bombarded. The isotope separation was accomplished by the use of a modified, multi-stage, Clusius and Dickel thermal diffusion column, employing hydrogen chloride gas at atmospheric pressure. The over-all length is 12 meters. After four days of continuous running a 40 cc sample was withdrawn at the bottom, dissolved in water, and activated simultaneously with a normal sample by bombardment with slow neutrons. The 37-minute beta-ray emission from Cl^{*38} of the two samples was compared simultaneously by means of two calibrated Geiger counters and the enriched sample was shown to contain 41.5 percent Cl^{37}. Targets of enriched and normal AgCl were bombarded with 3.3-Mev deuterons from a cyclotron and it was shown that the yield of the longest range group decreased relatively to the yield of the inside groups. This long range group is therefore due to $Cl^{35}(dp)Cl^{36}$ as expected. The group at $4.0Q$ value is therefore due to $Cl^{37}(dp)Cl^{38}$ and permits the calculation of the mass of Cl^{38}. The value obtained is 37.9803. This, using the known beta-ray upper limit of Cl^{38}, gives a mass of 37.9751 for A^{38} which agrees with the value from $Cl^{35}(\alpha p)A^{38}$.

5. Fast Neutron Threshold for Uranium Fission. R. O. HAXBY,* W. E. SHOUPP,* W. E. STEPHENS,* AND W. H. WELLS, *Westinghouse Research Laboratories.*—Using the neutrons from the Li (p,n) reaction, we have investigated the fast neutron excitation of fission in uranium. By increasing the proton energy, the maximum neutron energy is raised and the yield of fissions is measured by an ionization chamber and linear amplifier. The slow neutron fission background is minimized with cadmium and boron carbide shields, and with the use of sulfur insulation in the ionization chamber. The threshold is found to occur at a neutron energy of 0.35 ± 0.1 Mev.

* Westinghouse Research Fellow.

6. The Heat of Fission of Uranium. MALCOLM C. HENDERSON, *Princeton University.*—The heat produced during slow neutron bombardment in a 13.64g sample of metallic uranium was measured on a resistance thermometer.[1] Simultaneously the number of fissions produced in a 54-microgram layer of uranium was counted by an ionization chamber and pulse amplifier. The two uranium samples were within 1 cm of each other inside the same 1.27 cm lead shield and surrounded by 5.08 cm of paraffin. The source of neutrons was the Princeton cyclotron, using the beryllium-proton reaction at 6.5 Mev. The 54-microgram layer gave 40.1 ± 0.1 alpha-particles per minute into 2π solid angle and under slow neutron bombardment gave about 340 fissions per minute. At the same time the heat output was about 40 microwatts. Since thermal equilibrium is approached exponentially, the galvanometer deflection—the measure of the heat production—is the weighted and integrated effect of the heat produced in all preceding minutes. The heat produced in each minute is proportional to the number of fissions observed. A method of calculation based on these facts is necessitated by the continual fluctuation in the output of neutrons from the cyclotron, but has the advantage that every reading taken is significant. The weighted average of 13 runs, after various corrections which lower the result by 2½ percent, is 180 Mev per fission. The average deviation from this figure was 5 Mev and the maximum deviation was 12 Mev.

[1] M. C. Henderson, Phys. Rev. **56**, 703 (1939).

7. *P*-Wave Effects on Proton-Proton Scattering in the Meson Theory. HUBERT M. THAXTON, WILLIAM PRIVETTE AND DANIEL LEATHERBERRY, *Agricultural and Technical College of North Carolina.*—The potentials for the p-states derived[1] from the neutral meson theory are applied to the calculation of proton-proton scattering effects for the experimentally investigated energy region 670 to 1830 kev. The phase shifts K_1 are calculated by numerical integration and adjunction of Coulomb functions at $5e^2/mc^2$. The cut-off radius used was $0.46\hbar/\mu c = 1.006 \times 10^{13}$ cm with $\mu = 180$ m, corresponding to a potential which is constant inside the cut-off radius. The contribution to the ratio of scattering to Mott's due to the p-scattering is also calculated.[2] Series expansions in terms of energy are derived for the coefficients in the scattering formulas[2] and are used to calculate the coefficients necessary for the energies considered in these calculations for angles 15° to 45° at 5° intervals. For 670 kev the phase shifts are (−0.37°) for $V(^3P_0)$; (0.22°) for $V(^3P_1)$; (−0.09°) for $V(^3P_2)$ with an increase in value for the higher energies to (−1.72°) for $V(^3P_0)$; (1.11°) for $V(^3P_1)$; (−0.40°) for $V(^3P_2)$ at 1830 kev. A comparison of these phase shifts with those derived[3] for the attractive and repulsive p effects for the square and Gauss error well demonstrates that the p effects using the meson potentials are large and contribute appreciably to the ratio of scattering to Mott's value. The effect of change of mass $\mu = 180$ m to $\mu = 335$ m is being studied.

[1] H. A. Bethe, Phys. Rev. **57**, 260 (1940).
[2] G. Breit, C. Kittel and H. M. Thaxton, Phys. Rev. **57**, 255 (1940).
[3] H. M. Thaxton and A. M. Monroe, Phys. Rev. **56**, 616 (1939); A. M. Monroe and H. M. Thaxton, Phys. Rev. **56**, 616 (1939).

8. Pair Production by Electrons. J. R. FELDMEIER AND GEORGE B. COLLINS, *University of Notre Dame.*—The experimental values of the cross section for pair production by electrons, as determined by a number of investigators,[1] not only show large deviations from the theoretically predicted value, but also show discrepancies among themselves. The intense monochromatic source of electrons from the Van de Graaff generator at Notre Dame was employed for a study of the process of pair production by electrons in the energy range from 0.9 to 1.5 Mev, since this source offers a distinct experimental advantage over all the previous investigations, which employed β-rays. The trochoid method[2,3] of focusing was employed. The positron current was measured directly by collecting the positrons in a Faraday cage connected to an electrometer tube. This method was possible because of: (I) the high efficiency of the trochoid method of focusing; (II) the intense source of electrons available. A gold target 10^{-4} cm thick was irradiated with electron currents up to 10 μa. If the large experimental cross section ($\sim 10^{-22}$ cm^2) as found by a number of workers[1] is correct, this should result in a

positron current of 10^{-11} amp. per μa of incident current. Currents of this magnitude were not observed. There was, however, some indication of a positron current of 10^{-15} amp. per μa of incident current, which indicates a cross section for the process of pair production by 1.5 Mev electrons of the order of magnitude predicted by theory ($\sim 10^{-26}$ cm^2).

[1] See review article by H. R. Crane and J. Halpern, Phys. Rev. **55**, 838 (1939).
[2] J. Thibaud, *Quelques Techniques Actuelles en Physique Nucleaire*, (Gauthier-Villars, Paris, 1938).
[3] M. Monadjemi, J. de Phys. **8**, 347 (1937).

9. A Theory of Cosmic-Ray Phenomena Based upon a Single Primary Component. W. F. G. SWANN, *Bartol Research Foundation of the Franklin Institute.*—The fundamental assumptions and conclusions are: (1) There is only one type of primary radiation, a charged particle radiation —probably protons—of heavy mass. (2) The primary radiation has an energy spectral distribution with a lower limit determined by entry through the magnetic field. (3) By processes at present unknown, each proton on entering the atmosphere experiences a certain probability of splitting into ten mesotrons, and to a first approximation these mesotrons are born at rest in the system of axes in which the protons are moving. (4) Under the conditions of (3) the mesotrons born from the entering protons of minimum energy will have too short a life to get out of the stratosphere. Moreover, on disintegrating into electrons and neutrinos they will, on account of the low energy of the mesotrons, show approximation to symmetry of emission and provide for the flat intensity-zenith angle curve characteristic of high altitudes in these latitudes. (5) The mesotrons born of higher energy protons have greater energy and longer lives, so that they descend to the lower regions of the atmosphere and the electrons resulting from their disintegration perpetuate more completely their original path directions. (6) A spectral distribution which would provide an exponential law for the case of mass absorption of mesotrons will, in view of mean life considerations, give an absorption coefficient increasing with altitude and such as to simulate the participation of two components.

10. The Latitude Effect in Cosmic Rays at Far Southern Latitudes. E. T. CLARKE AND S. A. KORFF, *U. S. Antarctic Service and Bartol Research Foundation of the Franklin Institute.*—Cosmic-ray intensities have been measured at sea level using a single Geiger counter inside a lead shield 7.5 cm thick. The counts were scaled down 4 : 1 by a conventional thyratron circuit and then recorded on a dial recorder. Roughly 190,000 counts per day were recorded. The instrument was operated on board the *U.S.S. North Star* on its two voyages to Antarctica, reaching on the first a maximum geomagnetic latitude of 77°S. and on the second 57°S. It was found that the cosmic-ray intensity showed the well-known "knee" at approximately 39°S., and that between this latitude and 77° the intensity continued to rise slightly. The rate of rise in this portion of the curve, observed in February and March, was found to be the same as that reported by Compton[1] between 35° and 55°N. during the northern summer months. The total rise between the knee and 77°S. was found to be about 3 percent, while the "magnetic" latitude effect between the knee and the equator (at 78°W. longitude) was 8 ± 0.4 percent. It was found that if an external air temperature coefficient[2] of -0.25 percent per degree centigrade was applied to the counting rates obtained between the knee and 77°S., the curve of intensity against latitude in this region would be flat. The agreement obtained between the measurements with this counter and with electroscopes over this same course indicates that the specific ionization of the cosmic-ray particles does not, to within the accuracy of this determination, vary with latitude at sea level.

[1] A. H. Compton and R. N. Turner, Phys. Rev. **52**, 799 (1937).
[2] V. F. Hess, Phys. Rev. **57**, 781 (1940).

11. Single Scattering of Electrons. R. B. RANDELS, K. T. CHAO AND H. R. CRANE, *University of Michigan.*—The single scattering of electrons has been measured by means of a cloud chamber, for the following gases and energies:

GAS	ENERGY RANGE, MEV	LENGTH OF TRACK, METERS
Air	1.0– 4.5	800
A	1.0– 9.5	508
Kr	1.9– 9.5	112
Xe	1.5–11.5	804

Stereoscopic pairs of photographs were taken, although up to the present the angles have been measured in the projection only. The energy of each electron was measured, and in plotting the results the energies were separated into narrower ranges than those given in the table. The distributions obtained were compared with those calculated by projecting the Mott[1] distribution onto a plane. The plots for all the energy and atomic number groups were very similar to each other, in respect to their deviations from the Mott curve. The amount of scattering was in all cases greater than that predicted by Mott, by a factor of roughly 1.5, at those angles measured, namely greater than 15 degrees. It is to be noticed that the wild diversity of results (factors 0.1 to 30) for various atomic numbers and energies which one finds in the literature is absent. The credence given to our factor 1.5 will depend upon a careful investigation of possible systematic errors, rather than upon obtaining more tracks.

[1] N. F. Mott, Proc. Roy. Soc. **A124**, 440 (1929).

12. The Effect of Crystalline Structure on the Multiple Scattering of Electrons. N. L. OLESON, K. T. CHAO AND H. R. CRANE, *University of Michigan.*—Experiments[1] on the multiple scattering of electrons of 10^6 to 10^7 ev in lead have given significantly lower values than those calculated.[2] An important part of the multiple scattering is made up of numerous small deflections, of the same order as the angular separation between maxima in the crystal diffraction pattern. Therefore we must inquire whether diffraction phenomena such as extinction play an important part, since most scatterers used to date have been polycrystalline in structure. Wheeler[3] has probed into the question theoretically, and found reason to believe that the effect may be important in accounting for the apparent deficiency in the scattering by metallic lead. To test this, we have compared the multiple scattering in polycrystalline lead with that in a solution of lead chlorate in water. A cell

having 0.2-mm glass walls contained a layer of solution 2 mm thick. This contained 0.35 g of lead per cc. The scattering power of all the atoms of the cell other than lead was taken into account, but was small compared to that of the lead. At the dilution used, there could be little "order" among the lead atoms. Since the scattering power of the other constituents was comparatively small, the cell was very nearly equivalent to a lead gas. Three hundred and thirteen particles of average energy 6 Mev gave the same result as was obtained with an equivalent amount of polycrystalline lead. While it is still important to know theoretically the extent of this effect we believe we have shown that it is too small to account for the major part of the discrepancy in lead.

[1] C. W. Sheppard and W. A. Fowler, Phys. Rev. **57**, 273 (1940); N. L. Oleson, K. T. Chao and H. R. Crane, Phys. Rev. **57**, 1063A (1940).
[2] E. J. Williams, Proc. Roy. Soc. **A169**, 569 (1939); S. A. Goudsmit and J. L. Saunderson, Phys. Rev. **57**, 24 (1940).
[3] J. A. Wheeler, Phys. Rev. **57**, 352 (1940).

13. The Radioactive Isotopes of Gold. J. M. CORK AND J. HALPERN, *University of Michigan.*—In studying the radioactivity induced in gold two new emitters of half-life 54 hours and 164 days have been found. In addition the half-lives of three previously announced activities have been more precisely determined. The beta- and gamma-energies associated with each radioactivity have been measured by absorption methods and by the cloud chamber. Gold has a single stable isotope of mass 197 and while each of the five radioactivities can be reasonably assigned to a particular isotope, the placement is not as yet uniquely determined. The half-lives, energies and probable responsible isotopes appear to be as follows: 67.8 hr., β^- (0.74), γ (0.24, 0.50) [198]; 54 hr., β^- (0.57), γ (0.53) [195 or 196]; 5.6 days, β^- (0.36), γ (0.41) [196]; 164 days, β^- (0.45), γ (0.11) [199] and ~15 hr., (2.5) [?].

THURSDAY MORNING AT 9:30 O'CLOCK

Cathedral of Learning, University of Pittsburgh

Room 324

Supplementary Paper No. 55 will be called for after Paper No. 22

14. Abnormal Diamagnetism of Ge at Low Temperatures; the Specific Heat of Zr. CHARLES F. SQUIRE, *University of Pennsylvania.*—The diamagnetic susceptibility per gram of pure germanium changes from -1.0×10^{-7} to -1.0×10^{-6} in cooling through a transition of the cooperative type according to our measurements. The specific heat has a large hump at the transition (75°K) according to measurements of F. Simon and S. Critescu.[1] According to H. Nitka,[2] the x-ray evidence shows no change of crystal structure (diamond type) but about 1 percent contraction of volume on cooling through the transition. The large diamagnetism has an analogy in the case of Bi; it seems unlikely that it can be identified with the enormous diamagnetism of a superconductor. However, the transition may be caused by a cooperation between electrons so that a lower energy state is formed and so that electrons may move through large areas in the crystal under the influence of a magnetic field. We believe that a Debye $\theta=177$°K on the low temperature side and a $\theta=290$°K on the high temperature side of the transition explains the true abnormality of the specific heat curve. There is also a hump in the specific heat of Hf at 85°K;[1] we have therefore measured the specific heat of Zr down to 80°K but without finding the expected hump. A Debye $\theta=190$°K fits our curve very well.

[1] F. Simon and S. Critescu, Zeits. f. physik. Chemie **25**, 273 (1934).
[2] H. Nitka, Physik. Zeits. **38**, 895 (1937).

15. The Theoretical Magnetic Susceptibility of Molecular Deuterium as Compared with That of Molecular Hydrogen. ENOS E. WITMER, *University of Pennsylvania.*—The molar magnetic susceptibility χ_M of molecular hydrogen or molecular deuterium is given by

$$\chi_M=-\frac{Le^2}{6mc^2}(\overline{r_1^2}+\overline{r_2^2})+\frac{Le^2}{6m^2c^2}\sum_{n'\neq n}\frac{|P(n,n')|^2}{h\nu(n,n')}.$$

The first term has been evaluated exactly and the second approximately, using the wave functions of James and Coolidge for the normal electronic state of molecular hydrogen. Furthermore, a Morse wave function was used as the vibrational function in evaluating the first term. This function for D_2 differs from that for H_2, leading to slightly different values for the first term. Thus for H_2 the first term is -4.115×10^{-6} and for D_2 it is -4.080×10^{-6}. The second term in the formula above may also yield slightly different results for H_2 and D_2, but since the value of this term is less than 8 percent of the value of the first term, this difference is not important. The best value of χ_M for H_2 is probably -3.965×10^{-6}. Hence the value for D_2 should be about -3.93×10^{-6}.

16. The Fock Equations and Diamagnetic Susceptibility for Magnesium III. W. JACQUE YOST, *Brown University.*—The calculation of a self-consistent field including the exchange terms has been completed for Mg III in the normal state. The methods used are similar to those reported in the case of Mg III without exchange.[1] None of the final $Z(nl|r)$ diverge from self-consistency by more than ±0.003. Three approximations were necessary in both s

groups and four for the $2p$ group. The inclusion of the exchange terms produces a shift in the charge distribution in such a manner as to make the ion more compact. The $2s$ functions show a greater change than the $2p$ functions, which is contrary to results for similar configurations. The greater difficulty encountered in the numerical solution of the Fock equations is shown to arise from the inhomogeneity of the equations. An interpolation method is suggested for obtaining a good approximation to the solutions with exchange, whenever the solutions without exchange are known for the same configuration. The diamagnetic susceptibility for Mg III, as calculated from the solutions with exchange, is -3.74×10^{-6}. This is in good agreement with the value -3.3×10^{-6}, which Pauling[2] quotes as the best average value from several experiments. This calculation indicates that the earlier value of -8.6×10^{-6}, given by Joos,[3] is too high.

[1] W. J. Yost, Phys. Rev. **57**, 557 (1940).
[2] L. Pauling, Proc. Roy. Soc. **114A**, 204 (1927).
[3] G. Joos, Zeits. f. Physik **19**, 347 (1923).

17. Theory of the Approach to Magnetic Saturation. WILLIAM FULLER BROWN, JR., *Princeton University.*—Ferromagnetic saturation is not attained in finite fields because of internal forces that turn the spontaneous magnetization J_s out of the direction of the field H. These deviating forces are due to crystal anisotropy and to internal stresses. When they are uniform or vary slowly from point to point, a standard theoretical treatment[1] leads to a formula $J_s-J=b/H^2$. But if they change rapidly over short distances, this treatment is no longer valid; for then the interatomic coupling forces responsible for the spontaneous magnetization prevent it from changing its direction fast enough to follow the deviating forces exactly.[2] A calculation has been made for the case of deviating forces concentrated in points, lines, or planes. These lead to terms in J_s-J of the form $a/H^{n/2}$, with $n=1$, 2, 3, respectively, provided $H\ll$ or $\gg 4\pi J_s$; at intermediate fields the formulas are more complicated because of magnetic interactions. Experimentally[3] an a/H term is found as well as the b/H^2 term, and the coefficient a is increased by plastic flow. This suggests that the a/H term may be due to stress concentrations associated with dislocation lines.[4]

[1] F. Bitter, *Introduction to Ferromagnetism* (McGraw-Hill, 1937), p. 222.
[2] Cf. J. App. Phys. **11**, 160 (1940), especially Figs. 2 and 6.
[3] A. R. Kaufmann, Phys. Rev. **57**, 1089A (1940).
[4] J. M. Burgers, Proc. Phys. Soc. **52**, 23 (1940).

18. Electron Band Treatment of Susceptibilities of Nickel and Nickel Alloys. KENNETH E. KEYES, *Carnegie Institute of Technology.*—The temperature dependence of the susceptibilities of nickel and its alloys (nickel-copper and nickel-zinc) has been measured by various experimenters.[1] It has been found possible to explain this dependence formally by a straightforward application of the Fermi-Dirac statistics to the electron bands taking, of course, proper account of exchange forces. For nickel and its alloys the bands that need be considered are those arising from the ($3d$) and ($4s$) energy states. The theory of metals indicates that the proper distribution of the ($3d$) band near the top is given by $N(\epsilon)=a(\epsilon_m-\epsilon)^{\frac{1}{2}}$, while for the $4s$-bands the distribution is given sufficiently accurately for our purpose by $N(\epsilon)=\text{constant}=b$. By properly choosing the parameters a and b it is possible to obtain good agreement with experiment. The results are discussed in relation to the measurements of Keesom and Kurrelmeyer[2] on the specific heat of nickel-copper alloys at low temperatures. The present treatment differs from that of Stoner[3] in that it takes account of the presence of the ($4s$) band which overlaps the ($3d$) band.

[1] Mary A. Wheeler, Phys. Rev. **56**, 1137 (1939).
[2] W. H. Keesom and B. Kurrelmeyer, Phys. Rev. **57**, 1068A (1940).
[3] E. C. Stoner, Proc. Roy. Soc. **A165**, 372 (1938).

19. High Frequency Resistance and Permeability of Iron in a Magnetic Field. J. BARTON HOAG AND C. R. COX, *University of Chicago.*—The effect of a superimposed steady magnetic field on the high frequency resistance and permeability of iron has been investigated in the wave-length region from 11 to 160 meters. The substitution method of determining resistance was used in conjunction with a resonant circuit coupled to an oscillator. Permeabilities were computed from resistance measurements by the use of Kelvin's skin effect equation. It was found that the effect of an applied field is to reduce the permeability and the resistance of iron, the reduction amounting to 60 or 70 percent for fields of 850 oersteds. The percentage decrease in radiofrequency resistance due to the application of a field was found to be approximately constant over the range from 30 to 160 meters and to rise to a greater value at wavelengths less than 30 meters. The permeability with zero applied field was found to be approximately constant over the range from 30 to 160 meters and to decrease appreciably from 30 to 11 meters. A comparison will be made of the present permeability values (for $H=0$) with those of other workers in this range.

20. Magnetic Properties of Iron-Aluminum Alloys. R. M. BOZORTH, H. J. WILLIAMS AND R. J. MORRIS, JR., *Bell Telephone Laboratories.*—The alloy containing about four percent aluminum has been found to have a valuable combination of magnetic, electrical and mechanical properties. After melting in hydrogen or in air, rolling hot and then cold, and annealing at 1000°C, maximum permeabilities (μ_m) of over 25,000 have been attained. The cold rolling produces marked directional properties and in the direction of rolling and at right angles the permeability (μ) after annealing is as high as 8000 at a flux-density (B) of 14,000. In swaged rod, $\mu=12{,}000$ at $B=14{,}000$, and 7000 at 15,000, and the coercive force (H_c) is 0.20. After cold rolling and annealing for one hour, torque curves show that the directional character is marked when the annealing temperature lies between 700° and 1200°C. Special annealing in hydrogen at a high temperature reduces the coercive force to 0.08. The material is less brittle than iron-silicon alloys containing the same amount of silicon, the permeabilities at high flux-densities are higher than the commercial iron-silicon alloy and the resistivity is about the same. Ingots of 250 pounds have been satisfactorily cast and worked. Although μ_m is about the same as that previously

obtained,[1] H_c is much lower and μ is much higher at $B = 14{,}000$ and 15,000. The hysteresis loss at $B = 15{,}000$ is about one-tenth of that formerly reported.

[1] T. D. Yensen and W. A. Gatward, University of Illinois Bull. No. 95, 1–50 (1917).

21. Vicalloy, a New Permanent Magnet Material. E. A. NESBITT AND G. A. KELSALL, *Bell Telephone Laboratories.*—A new permanent magnet material with unusual mechanical as well as magnetic properties has been developed. In the best specimens, the coercive force (H_c) is 400 oersteds, the residual induction (B_R) 9600 gauss, and the energy product (BH) as high as 2.8×10^6. Before it is given its final heat treatment, it can be rolled and machined almost as readily as mild steel. The composition is 36 to 62 percent cobalt, 6 to 16 percent vanadium and 30 to 52 percent iron. The heat treatment and mechanical treatment used to attain the best magnetic properties were as follows: cast, hot swaged, cold drawn with a reduction in area as high as 95 percent, then heat treated for an hour at 600°C. Good mechanical properties and energy products as high as 1.0×10^6 are obtained without cold working. The alloy differs from most age-hardening alloys in that the γ phase stable at high temperatures is dispersed in the α phase stable at low temperatures, instead of vice versa. The cold work transforms γ to α and the anneal at 600°C transforms a part of the alloy to γ. This material is not commercially available at present.

22. Change of Length and Young's Modulus with Magnetization and Heat Treatment. H. J. WILLIAMS, R. M. BOZORTH AND H. CHRISTENSEN, *Bell Telephone Laboratories.*—The purpose of this investigation has been to study the changes in certain physical properties that result from different treatments given to an alloy in a temperature range reaching to 1000°C. The magnetostriction at saturation varied from 2.5×10^{-6} to 21×10^{-6} and the variation in Young's modulus with magnetization varied from 0.09 percent to over 8 percent. The alloy studied, permalloy containing 68 percent nickel, was chosen because it is especially sensitive to such heat treatments. The treatments were (1) the usual anneal followed by slow cooling, (2) the permalloy treatment (air quenched from 600°C), heat treatment (3) in a longitudinal and (4) in a transverse magnetic field. Measurements were also made on cold-rolled material before annealing. The results are interpreted in terms of the domain theory as far as possible. Young's modulus was determined by measuring the natural frequency of vibration of a hollow rectangle magnetized parallel to its sides so that the magnetic circuit was complete without air-gaps or end effects.

FRIDAY MORNING AT 9:30 O'CLOCK

Engineering Hall, Carnegie Institute of Technology

Room 209

Supplementary Paper No. 56 to be called for after Paper No. 33

23. Wave Reflections at Oblique Incidence. C. D. THOMAS AND R. C. COLWELL, *West Virginia University.*—In the troposphere, the temperature of the air does not always decrease with increased height above the earth's surface. Very frequently inversion layers are encountered at heights of from one to ten kilometers, in which there is an abrupt transition from cold dry air to warm moist air. The difference in dielectric constant between these two regions is sufficient to cause a reflection of radio waves. At perpendicular incidence the reflected wave is weak compared to the direct wave; but at oblique incidence, the reflected wave may be fairly strong. An application of Maxwell's equations to these boundary layers gives a quantitative relation which is in fair agreement with the experimental results. Short radio waves are bent around the curving surface of the earth by reflection from the inversion layers as well as by diffraction.

24. The Variation in Intensity of Radio Signals. R. C. COLWELL, *West Virginia University.*—For several years, the strength of radio signals from nearby broadcasting stations has been taken at midday. When the results are plotted, it is found in every case that the signals in winter are much stronger than in summer. There is also a day to day variation caused by the changing weather cycle.

25. The Influence of "Cold Ends" on Performance of Vacuum-Tube Air Coolers. I. E. MOUROMTSEFF, *Westinghouse Lamp Division, Bloomfield, New Jersey.*—Mathematical expressions are derived for longitudinal temperature distribution in a hollow cylinder under the assumption of uniform heating of the middle portion of the cylinder on the inside and uniform cooling on the outside of the entire cylinder. The results obtained are applied to a practical case of an air cooler designed for a vacuum tube with an external copper anode. Temperature distribution along the core of the cooler is calculated and represented graphically. The effect of variable air velocity on temperature distribution is discussed; curves for the "normal" and 50 percent and 200 percent of the normal velocity are calculated. Permissible anode dissipation is plotted as function of air velocity. It is shown that without taking the actual

temperature distribution into consideration an error of approximately +25 percent to −50 percent in maximum ratings can be made.

26. Arc Cathodes of Low Current Density at High Amperage. JOSEPH SLEPIAN AND W. E. BERKEY, *Westinghouse Electric & Manufacturing Company.*—From photographs, and from the marking on the electrodes, Slepian and Haverstick[1] found that short duration arcs of 25 amperes in gases at a pressure of a few centimeters had apparent current densities at the cathode of less than 100 amp. per cm². This is in sharp contradiction to the density of several thousand amperes per cm² which seems to be required by generally accepted theories of the cold cathode arc.[1] Similar results have been found up to currents of 5000 amperes, burning for 1/120 sec. with electrodes of various metals in air at less than 10 cm pressure. Apparent cathode current densities calculated from the observed marking on the electrodes were less than 1000 amp. per cm². The markings on the electrodes were apparently produced by oxidation only, the energy density developed at the electrodes being insufficient to bring the electrode surface to the melting point in the 1/120 second duration of the arc. The circuit interrupting capacity of these short low current density arcs was found to be not less than that of short arcs at atmospheric pressure.

[1] Phys. Rev. **33**, 52–55 (1929).

27. Short Time Photographs of a Low Pressure Copper Arc. R. C. MASON, *Westinghouse Research Laboratories.*—By the use of a narrow slit in a synchronously rotating disk as a shutter, photographs with an exposure time as short as 2×10^{-5} sec. have been made of a 200-amp. (peak) a.c. arc between copper electrodes in air at about 10 mm pressure. The light from the cathode region in general was diffuse, as if the cathode spot covered a comparatively large area. In a few photographs, the diffuse area appeared absolutely uniform in brightness, while in many cases there were in addition extremely small concentrated points of light on the cathode. The cathode current density, as judged from the diffuse area, would be from 200 to 1000 amp. per sq. cm. Two successive photographs, separated in time by 2×10^{-4} sec., as well as comparison of the marking left on the electrode by the arc with the photographs, revealed that the arc was usually in motion over the cathode. Typical photographs will be shown.

28. Simple Calculation of Klystron* Efficiency. E. U. CONDON, *Westinghouse Research Laboratories.*—The behavior of the energy modulated electron beam in an oscillation generator of the Klystron* type can be understood in a simple way by considering the trajectories of the individual electrons and averaging over the phase of the oscillation at which the various electrons enter the oscillating field. This point of view permits a simple calculation of Webster's approximate formula[1] for the efficiency of power conversion in the Klystron.*

* Sperry Gyroscope Company trademark.
[1] D. L. Webster, J. App. Phys. **10**, 501 (1939).

29. A Thermistor Voltage Regulator. C. B. GREEN AND G. L. PEARSON, *Bell Telephone Laboratories.*—Thermistor is a contraction of the words "thermal resistor" and designates an electrical resistance whose value is markedly dependent upon its temperature. Thermistors with a large negative temperature coefficient of resistance can be made of metallic oxides. One such thermistor which is commercially available is described and its thermal and electrical characteristics given. A considerable portion of its voltage-current characteristic has a negative slope, i.e., the voltage decreases as the current increases. This suggests a number of interesting applications for thermistors, among which is their use as automatic voltage regulators. If a properly chosen ohmic resistance is placed in series with the thermistor, the voltage drop existing across the terminals of the thermistor-resistance combination will remain constant despite a large variation of current through it. The electrical characteristics of a typical thermistor voltage regulator are presented and the effect of ambient temperature upon its operation discussed. A model regulator has been constructed which over a limited ambient temperature range will maintain a voltage of 13 volts to ±1 percent across a high impedance load when operating from a nominally 120 volt a.c. supply varying ±30 percent, or from a 35-volt supply varying ±20 percent.

30. A Magnetic Ultra-Micrometer for Measurement of Thin Films or Nonmagnetic Material Superimposed Upon a Base of Magnetic Material.—W. B. ELLWOOD, *Bell Telephone Laboratories.*—A magnetic bridge is described which measures without destruction the average thickness over a given area of a nonmagnetic film of any kind upon one side of a magnetic base material. The thickness is in terms of an equivalent resistance or galvanometer deflection and is empirically calibrated and is only slightly affected by large variations in the permeability of the base material. The sensitivity of the bridge can be made to detect 10^{-6} inches of film. The bridge consists of two short collinear magnetic probes provided with primary windings excited with a.c. The test specimen is clamped between the ends of the probes perpendicular to them and the differential voltage between two secondary coils on the probes is a measure of the thickness of the film. This a.c. e.m.f. is measured by a d.c. galvanometer which is connected to the coils through a vibrating reed rectifier enclosed in glass which is driven synchronously by the a.c. power supply to the bridge. This device provides ample sensitivity without amplification.

31. The Effect of Pressure Variation of Viscosity on the Lubrication of Plane Sliders. M. MUSKAT AND H. H. EVINGER, *Gulf Research & Development Company.*—The Reynolds theory has been applied to the calculation of the lubrication properties of plane sliders—thrust bearings—of infinite width provided with lubricants whose viscosities increase with the pressure. The variation of viscosity with pressure was assumed to be exponential. The important variable characterizing the lubricant and the effect of the pressure variation of its viscosity was found to be the

product of the viscosity pressure exponent and the bearing load per unit area. Curves for the friction coefficient, minimum film thickness, and lubricant flow were calculated for fixed values of this product, both for fixed wedge angle and pivoted sliders. It was found that for each choice of this product there will be a limiting position of the pivot line of the slider or of the equivalent Sommerfeld variable at which the film pressures and friction forces would become infinite, and beyond which it will be impossible to operate the slider. Moreover the absolute maximum value for this product under any conditions was found to be the value 2. This means that the absolute maximum load per unit area which can be carried by such bearings is equal to twice the reciprocal of the viscosity pressure exponent.

32. Experiments on Boundary Lubrication. F. MORGAN, M. MUSKAT, AND D. W. REED, *Gulf Research & Development Company.*—Apparatus has been constructed somewhat similar to that of Bowden to study the stick-slip behavior of the friction and temperature at the contact between metallic sliders under various conditions of speed and load, with different types of surfaces, and with sliders having given periods of free vibration. Simultaneous records were obtained of the instantaneous values of the friction and temperature. The friction determinations were made by reflecting light directly from the vibrating element onto a photographic film. The temperature fluctuations were recorded in terms of the thermoelectric voltages generated between the sliding surfaces which, after amplification, were sent to a high frequency galvanometer recorder. To check that these voltages were not due to spurious effects records were obtained for the sliding of steel on steel. In these no thermoelectric voltage was observed even though the friction traces showed large fluctuations. For constantan on steel the characteristics of the traces were found to depend on the relative speed and load, as well as on the natural frequency of the vibrating element. Preliminary results indicate that under certain conditions of lubrication some stick-slip may still take place while in other cases it disappears entirely and no temperature jumps occur.

33. Precipitation of Dirt. R. A. NIELSEN, *Westinghouse Research Laboratories.*—The unwanted deposition of dirt and smoke on room walls is a nuisance in industrial cities; this is especially true in a community where soft coal is used as a fuel. The deposits that occur are of two kinds: a uniform deposit resulting in a fairly inconspicuous darkening of the walls; and patterned deposits silhouetting laths, studdings, nails, etc., that often become very conspicuous before the end of a heating season. The action of convection, diffusion, and thermal gradients in producing the deposits that are observed on the walls will be discussed. Data on the magnitude of thermal gradients near wall surfaces of homes will be presented together with suggestions for minimizing the deposition of dirt on walls.

FRIDAY MORNING AT 9:30 O'CLOCK

Engineering Hall, Carnegie Institute of Technology

Room 218

34. On the Heat Emission Associated with the Processes in Oversaturated Solid Solutions ("Aging"). H. CALUS AND R. SMOLUCHOWSKI, *Warsaw Institute of Technology and Princeton University.*—"Aging" a process little understood, especially at its early stages, occurs in oversaturated solid solutions which lead to precipitation. Its study is interesting in view of the problem of mechanism of diffusion in crystal lattice and equilibrium conditions. The process is accompanied by changes of mechanical, electric and magnetic properties and is important for the applications of duraluminum alloys. As a further step in its study, in particular of the rate of reaction, accurate measurements were made of the heat effects associated with the beginning of aging. The Swietoslawski microcalorimetric technique used before for similar research was applied. The method of measurements consisted in following the change of temperature difference between a quenched metal block and a thermostat (±0.002°C) by means of a differential thermocouple. One obtained the rate of heat emission from the formula: $H=c[m-k(t_0-t)]$ where m is the slope of the time-temperature curve, t_0-t the thermocouple indications, k a constant, and c the specific heat. The results were checked by an adiabatic method in which the thermostat and the block have the same temperature. One was able to make measurements soon enough after the quenching to observe the increase of the heat emission before it reaches a maximum and decreases asymptotically. It was thus possible to measure the total heat and the value 1.75±0.05 cal. per gram was obtained for Duralumin. Studies were made on the influence of temperature of aging on the heat emission, and also of the composition for pure Al-Cu alloys (up to 5 percent Cu by weight). The heat emission increases with the amount of copper, being zero for pure aluminum.

* W. Swietoslawski and J. Czochralski, Wiad. Inst. Met. **3**, 59 (1936).

35. Field Emission X-Ray Tube. C. M. SLACK, *Lamp Division, Westinghouse Electric & Manufacturing Company.*—It has been found possible to draw currents of the order of several thousand amperes from cold metals by field emission in vacuum. This principle has been put to use in the design of a condenser discharge x-ray machine for

high speed radiography. For a practical tube it seems necessary to use an auxiliary electrode spaced close to the cathode and connected to the anode through a high resistance. This electrode serves to initiate the discharge which is then transferred to the anode. It can also be made to serve as a focusing electrode. Radiographs of bullets and other high speed objects will be shown.

36. An Attempt to Measure Young's Modulus and Poisson's Ratio by X-Ray Methods. L. L. DAVENPORT, *University of Pittsburgh.* (*Introduced by S. S. Sidhu.*)—Measurements of longitudinal extension and transverse contraction of polycrystalline tungsten wires under stress have been made by back reflection photograms using Ni $K\alpha$ radiation. The effect of strain in 321 direction has been determined. The preliminary results appear satisfactory and indicate an additional possibility of a determination of the yield point. A method of measuring radii of diffraction rings has been developed. The values for a single crystalline direction may be computed by this technique.

37. Atomic Distribution in Aluminum-Silver Alloys During Aging. CHARLES S. BARRETT AND ALFRED H. GEISLER,* *Carnegie Institute of Technology.*—Laue photographs of aluminum-rich aluminum-silver crystals during aging at 20° and 150°C show more or less clearly defined streaks along certain zonal ellipses, in addition to the streaks caused by thermal agitation. These have been analyzed by stereographic and reciprocal lattice projections and are found to result from cross-gratings parallel to planes of the form {111}. The streaks with 20° aging are more diffuse than with 150° aging; no streaks were found with 200° aging. When actual precipitation occurs, sharp spots appear along the streaks at places predicted from earlier studies of the Widmanstatten structure[1] formed by the visible precipitated crystals. Two theories can account for the cross-grating diffraction: (a) silver atoms collect in plate-like clusters on irregularly spaced {111} planes in a way analogous to that proposed in aged aluminum-copper alloys,[2,3] and (b) certain {111} planes shift parallel to themselves as required for the transformation from face-centered cubic to hexagonal close-packed lattices, the shift occurring on random planes in such a way as to destroy the periodicity normal to the planes.

* Aluminum Company of America Graduate Fellow.
[1] R. F. Mehl and C. S. Barrett, Trans. Am. Inst. Min. Met. Eng., Met. Div. 78, 1931.
[2] A. Guinier, Comptes rendus **204**, 1115 (1937); **206**, 1641 (1938); Nature **142**, 569 (1938).
[3] G. D. Preston, Nature **142**, 570 (1938); Phil. Mag. **26**, 855 (1938); Proc. Roy. Soc. **A167**, 526 (1938).

38. X-Ray Diffraction Studies of Anhydrous Chromic Oxides Prepared by Different Methods. S. S. SIDHU, *University of Pittsburgh,* AND MARC DARRIN, *Mellon Institute.*—Anhydrous chromic oxides prepared by different methods and analyzing from 99 to 100 percent in purity show marked differences in their physical properties. They vary in appearance from a very bulky powder to a very dense, visibly crystalline material. Their crystalline structure, however, remains the same, rhombohedral (hexagonal system). The size of the unit cell in each case has the normal x-ray value. Powder diffraction photograms prepared with standard-size specimens and a camera of the same effective diameter are identical with respect to the number and positions of the diffraction lines, but the intensities of the corresponding lines originating from the same crystal planes vary considerably, depending upon the method of preparation. For example, in some samples the 102 and 110 intensities are exactly the same, but in others the former increases and the latter decreases. Whether the intensity anomalies result from (1) the orientation of scattering centers owing to the movement of the molecules, (2) the formation of unstable small crystallites in which the molecules from certain crystal planes diffuse to other planes as the size of the crystallite grows, or (3) a temporary substitution of oxygen atoms for chromium atoms, as in the passivity of chromium, will be discussed.

39. An Electron and X-Ray Diffraction Study of the Grain Boundary Substance in Cadmium. BERNARD L. MILLER, *University of Pennsylvania.* (*Introduced by Raymond Morgan.*)—All metals in their usual state consist of a conglomeration of microscopic grains. Insoluble impurities collect at the boundaries of these grains and form films between the crystals. As such they may exercise considerable influence on the mechanical, diffusion, corrosion, recrystallization, electrical and magnetic properties of the metal. The grain boundary material in commercial cadmiums was isolated by dissolving laminae of cadmium in ammonium nitrate solution, the boundary substance remaining as insoluble films. Electron diffraction patterns were made of such films using 40 to 50 kilovolt electrons and x-ray diffraction patterns were obtained of powders of these films employing copper $K\alpha$-radiation. Guided by a knowledge of the elements present as indicated by a spectrographic analysis, the diffraction patterns were identified as belonging to the compounds cadmium carbonate and basic lead carbonate. Since it is known that normal lead carbonate converts to basic lead carbonate in ammonium nitrate solution it is concluded that cadmium carbonate and normal lead carbonate were present at the grain boundaries in the cadmium metals.

40. X-Ray Diffraction Studies of Silver-Rich, Silver-Magnesium Alloys. HAROLD R. LETNER, HENRY H. GEORGE AND S. S. SIDHU, *University of Pittsburgh.*—A preliminary survey of the α and β solid solutions of magnesium in silver has been made using a Debye-Scherrer camera and Cu $K\alpha$-radiation. The lattice parameters of both the face-centered cubic α-phase and the body-centered cubic β-phase are found to increase with increasing magnesium content. Line intensities of alloys in the β-phase, allowed to cool in the furnace, indicate a highly ordered structure in the region of 50 percent magnesium. Quenched alloys having compositions in the two-phase region between the α- and β-phases and also some of the alloys in the β-phase annealed for 113 hours at 775°C, exhibit substantially less order. Further experimental work to study the magnesium-rich, silver-magnesium alloys is in progress.

41. X-Ray Absorption Edges in Gaseous, Liquid and Solid States. T. DRYNSKI AND R. SMOLUCHOWSKI, *Warsaw University, Warsaw, and Princeton University.*—The fine structure of the x-ray absorption edges depends mainly upon the structure of the energy spectrum above the occupied levels and on the transition probabilities. Although a quantitative interpretation is not always possible it is of interest to compare the fine structure of the x-ray absorption edges in gaseous, liquid and solid states. As absorbing substances were chosen: (i) $GeCl_4$, which in gaseous state has a Ge *K*-edge which structure is experimentally and theoretically known; (ii) $AsCl_3$, which has a similar molecular structure. Special experimental arrangements have been developed in order to obtain a thin layer of absorbing substance in liquid (room temperature) and in the solid (melting point for $GeCl_4$ −52°C, for $AsCl_3$ −18°C) state. The absorbing substance was kept in both cases in a thin glass capillary tube of proper inside diameter and thin walls. The structure of the Ge *K*-edge of solid $GeCl_4$ differs considerably from that obtained with both liquid and gaseous $GeCl_4$, the structure in the two latter states being practically identical. For $AsCl_3$ the edges in the case of gaseous and liquid state were obtained and show in general the same effects as for $GeCl_4$. The results are in accord with general qualitative expectations which one can formulate in considering the characteristic features of the gaseous, liquid and solid states.

42. An X-Ray Study of Liquid Benzene, Cyclohexane, and Their Mixtures. WHEELER P. DAVEY AND PAUL H. BELL, *The Pennsylvania State College.*—X-ray (Mo *K* alpha) studies were made of pure benzene, pure cyclohexane, and their mixtures, by using a Geiger-Mueller counter with balanced filters. The benzene showed at 25°C a rather sharp intense peak at the customary 8°40′ and a new broader peak of about one-eighth intensity at 4°20′. The cyclohexane showed a similar pair of peaks at 8°0′ and 4°0′. The mixtures all showed a broad peak of low intensity reaching from 4° to 8° and three sharp peaks at 8°0′, 8°20′, and 8°40′ superimposed on a broad peak which reached from about 8°0′ to about 8°40′. The positions of the three sharp peaks were not affected by the proportions of the two components, and their relative intensities are independent of amount of stirring. The customary shift with temperature was observed on all peaks. The results are consistent with a cybotatic type of picture. Benzene is pictured as having short-lived highly organized groups of *–B–B –B–B–* floating in a chaotic sea of disorganized benzene molecules. The peak at 8°40′ is thought to be due to resonating groups of *–B—B–B—B–B—B–* and *—B–B– –B–B—B–B—*. Cyclohexane would contain similar groups of *–C–C–C–C–*. The mixtures are assumed to contain *–B–B–B–B–*, *–C–C–C–C–*, and *–B–C–B–C–*. The presence of any considerable amount of more complicated groupings is obviously highly improbable.

43. The Structure of Liquid Argon. E. P. MILLER AND K. LARK-HOROVITZ, *Purdue University.*—A special high vacuum camera has been constructed which allows the investigation of liquids at low temperatures in a plane parallel cell with mica windows 0.01 mm thick and about 4 mm in diameter. Liquid argon in a layer 1.3 mm thick has been investigated at a pressure of 810 mm Hg with monochromatic Mo $K\alpha$-radiation. The diffraction pattern shows three distinct rings at $\sin\vartheta/\lambda$: 0.152, 0.284, 0.410 and a faint ring at $\sin\vartheta/\lambda \sim 0.59$. From a Fourier analysis the atomic distribution curve has been determined: there are about 10 nearest neighbors in a distance of 3.80A (as compared to 12 neighbors at 3.82A in the solid). This number is comparable to the 9.8 Cl atoms found around any Cl atom in LiCl as reported some time ago. A concentration of next nearest neighbors is indicated at 5.4A and further concentrations at 6.7A and 7.9A. From these results we conclude that the transition solid-liquid in argon produces a disorder without however changing the essential pattern of coordination as observed in the solid.

FRIDAY MORNING AT 9:30 O'CLOCK

Engineering Hall, Carnegie Institute of Technology

Room 60

Papers Nos. 46 and 54 will be read by title.

44. The Diffraction and Reflection of Molecular Beams. WILLIAM H. BESSEY, *Carnegie Institute of Technology.**—The diffraction and reflection of helium atoms and hydrogen molecules by lithium fluoride cleavage surfaces were studied by the method of molecular beams. A search was made for diffraction maxima very close to the specularly reflected beam; their presence would be direct evidence for the secondary structure of crystals postulated by Zwicky. The results were negative. Anomalous reflection curves were found, however, which were similar to those obtained by Renninger[1] for the reflection of x-rays by certain rock salt crystals. Both results can apparently be explained by assuming that crystals are made up of small pieces, crystallites, which are slightly tipped with respect to each other.

* Now at the South Dakota State School of Mines.

[1] M. Renninger, Zeits. f. Krist. **89**, 344 (1934).

45. On the Color of Solutions of Alkali Metals in Ammonia. HANS VON R. JAFFE, *Allegheny College.*—The concentrated solutions of alkali metals in liquid ammonia

show metallic reflection with a remarkable dependence of the color of the reflected light on the angle of incidence. For the extreme case of the saturated solution of lithium the author has reported[1] a change of color from deep red to yellow, green, and finally white as the angle of incidence was increased from 0 to 90°. Measurements of the Hall effect of the solid compound $Li(NH_3)_4$ carried out at the same time led to the conclusion that the solid compound as well as the saturated solution contains one free electron for each atom of Li present. It is now shown that, using this electron density, the classical theory of dispersion of free electrons satisfactorily accounts for the observed color phenomena. To explain the absorption spectra of the dilute solutions the potential energy of the electron in the field of surrounding NH_3 molecules must be taken into account. An energy of 1 ev would be in agreement with the data on absorption so far available.

[1] Hans Jaffe, Zeits. f. Physik **93**, 741 (1935).

46. Halation on Kinescope Screens. RICHARD F. BAKER, *Columbia University.**—Halation in the conventional kinescope is caused by light which has returned to the phosphor by way of total internal reflection and has then been scattered. Halation is objectionable in television reception because of the resultant loss of contrast and is especially annoying in any quantitative oscillograph work. The use of an absorbing medium between the phosphor and the glass envelope or in the glass itself for reducing halation has been proposed, and in conjunction with a small degree of optical contact between the phosphor and the glass is quite effective. Another method for minimizing halation is to combine with the advantages of an attenuating film a high index of refraction n_m which is greater than the index of either the glass n_g or the phosphor n_p. An analysis taking account only of the two total reflections at the film-glass and glass-air interfaces and assuming the validity of Lambert's law shows that the fraction of the total flux leaving an elementary area of the phosphor which reaches the air is

$$\log (1-1/n_m^2)^{\frac{1}{2}}/\log (1-n_g^2/n_m^2)^{\frac{1}{2}}.$$

For the conventional phosphor-glass combination the fraction is

$$\log (1-1/n_p^2)^{\frac{1}{2}}/\log (1-n_g^2/n_p^2)^{\frac{1}{2}}.$$

In all cases where $n_m > n_p > n_g$ the film offers an advantage insofar as the percentage of flux returning to the phosphor is concerned. This advantage of the film is increased when the absorption of the halo-forming flux in the film is taken into account. The advantages of this method in practice may be realized by depositing a film of high refractive index, low absorption index and low reflection coefficient between the phosphor and the glass envelope. The increase in contrast achieved in this manner is of course attained at the expense of spot intensity due to attenuation in passing through the film.

* To be read by title.

47. Rotational Structure of Some Fundamental Infra-Red Bands of Deuterated Formic Acid. LINCOLN G. SMITH AND V. WILLIAMS, *Princeton University.*—The rotational structures of the following infra-red bands have been obtained: ν(C−H) in HCOOD, ν(C−D) and ν(O−D) in DCOOD, and ν(C−D) in DCOOH. The approximate band centers are, respectively, 2944, 2232, 2632, and 2219 cm^{-1}. The ν(C−H) band of HCOOD is similar to that of HCOOH previously reported[1] in that no qQ branch is present, whereas each of the other three shows a definite qQ branch. This indicates that the axis of least moment of inertia is perpendicular to the C−H bond in HCOOH and HCOOD, but is appreciably shifted from this position when deuterium is substituted for the carbon hydrogen. The similarity of the ν(O−D) and ν(C−D) bands in DCOOD shows that these bonds make approximately equal angles with the axis of least moment of inertia. These results are in qualitative agreement with the structure of formic acid presented by Badger and Bauer. The structure of the molecule will be further discussed in the light of these new data.

[1] Paper No. 117, Washington meeting, April 26, 1940.

48. Transmission Line Method of Measuring the Dielectric Constant of Gases and Water Vapor at Ultra-High Frequencies. JOHN P. HAGEN, M. DISTAD AND F. C. ISELEY, *Naval Research Laboratory.*—A concentric transmission line, with the inner conductor a quarter wavelength long and grounded to the outer sheath at one end, was loosely coupled to an external ultra-high frequency oscillator. A detector was also loosely coupled to the quarter-wave line and the frequency of the oscillator adjusted to produce resonance in the line. Measurements were made of the resonant frequency first with dry air surrounding the inner conductor and then with moist air at various humidities and temperatures. Since the dielectric constant of the surrounding gas is inversely proportional to the square of the resonant frequency, the dielectric constant of the gas can be readily calculated. The experimental results for water vapor at 50°C with a frequency of 150 megacycles agree very well with those of other workers using frequencies below one megacycle. This shows that the dielectric constant of water vapor is practically independent of frequency up to at least 150 megacycles. This method is also suitable for measuring the dielectric constant of other gases at ultra-high frequencies.

49. Ultrasonic Absorption in Liquids. E. C. GREGG, JR., *Case School of Applied Science.*—The absorption coefficient in liquids was determined by measuring the voltage which must be applied to the vibrating crystal in order to bring the points of convergence[1] of parallel light into focus in a microscope set at various distances down the sound beam.[2] As was expected by theory, a linear relationship was found between the square root of the voltage and the reciprocal of the convergence distance and also between the logarithm of the voltage and the distance of the light beam from the radiator along the sound beam. In the latter case, the absorption coefficient was measured as a function of the slope of the line. Values of α (Biquard's notation) at 1901.5 kc are as follows: benzene, 0.032; toluene, 0.0099; and chloroform, 0.051. Due to unequal amplitudes of

vibration present over the surface of the crystal[3] and the corresponding effect on the depth of focus, a quantitative estimate could not be made of the errors involved. Investigation of the values of the absorption coefficient, presented both above and in the literature, shows that for most liquids the absorption over the frequency squared becomes a constant only above a frequency of about one megacycle. Only an approximate correlation appears between viscosity and absorption.

[1] Lucas and Biquard, J. de Phys. et le Rad. **3**, 464 (1932).
[2] Gregg, Abstract 6, Kenyon Meeting of Am. Phys. Soc., April 6, 1940.
[3] Dye, Proc. Roy. Soc. London **A138**, 1 (1932).

50. Absorption of Supersonic Waves in Gases. I. F. ZARTMAN AND FRED H. SMITH, *Muhlenberg College.*—The absorption of supersonic waves in CO_2-free dry air, H_2 and CO_2 was measured at a frequency of 606 kc at room temperature and atmospheric pressure. The variable path acoustic interferometer developed by Hubbard was used, precautions being taken to insure the maintenance of plane parallelism between reflector and source for all positions of the reflector, proper support for the crystal and prevention of acoustic radiation from the unused face of the crystal. Contamination of the purified gases was avoided by using only metal, glass and quartz in the construction of the apparatus. The following energy absorption coefficients were obtained: CO_2-free dry air, 0.244; H_2, 0.334; CO_2, 1.46.

51. The Theory of Gaseous Isotope Separation in a Force Field with Application to the Ultracentrifuge. G. HAROLD WILSON, *University of Delaware.* (*Introduced by Enos E. Witmer.*)—This investigation deals with the problem of the rate of change of concentration of each component kind of molecule in a mixture of isotopic molecules when in a field of force. A kinetic theory derivation of the equation for the transport of molecules in a field of force is given for each component in the mixture. From this are derived the differential equations governing diffusion in a force field. The diffusion equations were solved subject to the conditions obtaining in an ultracentrifuge of special form by means of a differential analysis. These solutions are used to make a calculation for a typical case. Approximate analytic expressions for the solutions of the fundamental differential equations are obtained which are valid if the speed of the centrifuge is not too high. Other expressions which hold if the force field is constant are also derived.

52. Elasticity of Solids at Different Temperatures, Especially Near Phase Transitions. H. F. LUDLOFF, *Cornell University.*—As indicated,[1] the thermoelastic properties can be computed from the solid state theory. One needs an equation of state relating the internal pressure of a solid to its volume and temperature. In general it is sufficient to consider one term referring to the pressure of the electrostatic forces and another term containing the pressure of the thermal waves. However, near phase transition regions a third term has to be added which takes into account the configurational change in the lattice during the transition. This term, according to Bethe and Kirkwood,[2] yields the expression:

$$p_3=\int_0^T C_p^{au}dT\times\frac{1}{v}\frac{\partial V}{\partial v}$$

(C_p^{au} anomaly in the specific heat curve, V interaction energy between neighboring atoms). It is shown that $V(v)$ can be computed if C_p has been measured. An equation of state containing these three terms enables one to compute the variation of the elastic parameters for all temperature ranges. At low temperatures one gets a T^4-law, at high temperatures a T-law; the elastic behavior near phase transitions can be derived if measurements of one of the thermal parameters are available.

[1] Phys. Rev. **57**, 558 (1940).
[2] Bethe and Kirkwood, J. Chem. Phys. **7**, 578 (1939).

53. A Self-Consistent Solution to the Vacancy Problem in Metals. H. B. HUNTINGTON, *University of Pennsylvania.*—Previous calculations have indicated a preference for the hole mechanism for substitutional diffusion, but the nonorthogonality of the wave functions then employed made quantitative estimates of the involved energies somewhat unreliable. A more thoroughgoing procedure was here followed—namely to find a Hartree-Foch self-consistent solution for the electrons in the neighborhood of the vacancy. A free electron model was used with parameters fitting the copper lattice. Initially analytic functions, determined from a square barrier approximation, were used to calculate the exchange potentials for S and P functions. An electrostatic potential was also determined. With these fields the wave functions were integrated, and a repetition of the process brought a reasonable degree of self-consistency. Preliminary calculations give a value of about 2 to 3 ev for the energy needed for the formation of a hole.

54. Pressure-Temperature Dependence of the Compressibility Factor and Density of Hydrocarbons.* BRUCE L. HICKS, *University of Wyoming.*—Several successful empirical equations which describe the P-d-T relations of liquids and gases have been of the form $P=P(T, d)$, which is indicated by theoretical treatments. However, for many purposes it is desirable to know some inverse function such as density or volume as a function of temperature and pressure. Especially useful in applications is the function $Z(T, P)=PV/RT$, the compressibility factor, and, particularly at low pressures, the function $\underset{\sim}{V}(T, P)=(RT/P)-V$, the residual volume. The inverse functions, Z and $\underset{\sim}{V}$, and likewise the density d may be calculated from the function $P=P(T, d)$ by means of Lagrange's formula for the reversion of series. The expressions are

$$\frac{P(T,d)}{d}=\frac{P}{d(T,P)}=ZRT=RT+\frac{P}{RT}\left[\frac{\partial}{\partial d}\left(\frac{P(T,d)}{d}\right)\right]_{d=0}-\sum_{n=1}^{\infty}\frac{P^{n+1}}{(n+1)!n}\left[\frac{\partial^{n+1}}{\partial d^{n+1}}\left\{\frac{d}{P(T,d)}\right\}^n\right]_{d=0},$$

from which $\underset{\sim}{V}$ may be obtained since $\underset{\sim}{V}=(1-Z)RT/P$, and

$$\frac{d}{P(T,d)}=\frac{d(T,P)}{P}=\frac{1}{RT}+\sum_{n=1}^{\infty}\frac{P^n}{(n+1)!}\left[\frac{\partial^n}{\partial d^n}\left\{\frac{d}{P(T,d)}\right\}^{n+1}\right]_{d=0}.$$

With the help of Faa' di Bruno's formula[1] for the derivatives of a function of a function, the necessary partial derivatives of the functions $\{d/P(T, d)\}^m$ taken for $d=0$ may be computed directly without forming the intermediate derivatives. Explicit calculation of the coefficients of some of the lower powers, P^n, using a recently developed equation of state, $P=P(T, d)$ for the saturated hydrocarbons,[2] will be reported in the near future. These coefficients will be polynomials in T and $1/T$ as are the coefficients of d^n in the original function, $P(T, d)$.

* To be read by title.

[1] F. Faa' di Bruno, Annali di Scienze Matematiche e Fisiche di Tortolini **6**, 479 (1855).

[2] Benedict, Webb and Rubin, J. Chem. Phys. **8**, 334 (1940).

SATURDAY MORNING AT 9:30 O'CLOCK

Mellon Institute Auditorium

Entrance From Bellefield Avenue

Symposium of Invited Papers

on

Applied Physics

1. **The Theory of Internal Strains in Solids.** FREDERICK SEITZ, *University of Pennsylvania.* (40 minutes)
2. **Gasoline.** PAUL D. FOOTE, *Gulf Research and Development Company.* (40 minutes)
3. **Physical and Chemical Characteristics of Explosives and Their Military Applications.** R. H. KENT, *Aberdeen Proving Ground, War Department.* (40 minutes)

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member one only of these will be assigned a place on the regular program while the others will be placed in a supplementary program to be called for if time permits.

The papers in the supplementary program may be called for only at the session indicated.

55. Explanation of Anomalous Magnetic Torque Curves.* R. M. Bozorth and H. J. Williams, *Bell Telephone Laboratories.*—When a disk cut from a cubic crystal of a ferromagnetic material is placed in a magnetic field parallel to its plane, the torque exerted on the disk by the field generally increases continually with the strength of the field, approaching a finite limit (saturation) in very high fields. An exception to this course for one orientation of a crystal of iron-silicon alloy has recently been observed by Tarasov.[1] We have confirmed his findings and observed a similar effect for a series of orientations of disks cut parallel to the (110) and (100) planes. As the field strength is increased, the torque passes through a well-defined maximum before beginning the final approach to saturation. This "anomalous" peak is explained in terms of the well-known energy equation:

$$E = E_K + E_H = K_1(\alpha_1^2\alpha_2^2 + \alpha_2^2\alpha_3^2 + \alpha_3^2\alpha_1^2) - HI_s \cos\theta,$$

in which the α's are the direction cosines with respect to the crystal axes of the magnetization vector (I_s) of one domain and θ is the angle between I_s and H. As H increases, the path traced on a sphere by the end of the vector I_s is determined by minimizing the energy for specific values of H. The graphical method developed is simple and can be used for calculating torque and magnetization curves for any direction of the applied field. A necessary condition for the occurrence of the peak is that $dE_K/d\theta$ have a maximum between the direction of H and the nearest direction of easy magnetization. In (100) disks the demagnetizing factor must be small.

* To be called for after Paper No. 22.
L. P. Tarasov, Phys. Rev. **56**, 1224 (1939).

56. Spark Gaps with Short Time Lag.* Joseph Slepian and W. E. Berkey, *Westinghouse Electric & Manufacturing Company.*—Short spark gaps (order of one mm) in air at atmospheric pressure, unless specially radiated, show large spark lag when tested at little above the sparking potential. In engineering literature this property is measured by the impulse ratio, i.e., the ratio of the voltage at which breakdown occurs under a voltage surge rising at a specified rate (about 50 kilovolts per microsecond) to the voltage at which breakdown occurs with slowly increasing impressed 60-cycle voltage. The spark lag shows statistical variations, and its mean has been shown to be nearly equal to the mean time for emission of an electron from the cathode, prior to the spark.[1] The electron current from the cathode prior to the spark is greatly increased by the presence of a pointed projection on the cathode, so that the mean spark lag at a given voltage is greatly reduced. However, if a single pointed projection is used, of sufficient size to reduce the spark lag at a given voltage, it also reduces the 60-cycle sparking potential, so that the impulse ratio, which is the quantity important in engineering applications, is not reduced. By using a very large number of extremely small pointed projections on the cathode, the spark lag can be reduced without appreciable lowering of the 60-cycle sparking potentials. Thus impulse ratios little greater than unity can be obtained. Small particles of carborundum, rutile, Alundum and porcelain of various sizes were attached to the cathodes of spark gaps, and the impulse ratios tested. Minimum impulse ratios were obtained when the particle linear dimensions were between 2×10^{-3} and 15×10^{-3} cm.

* To be called for after Paper No. 33.
[1] R. Strigel, Wiss. Veröff a.d. Siemens-Konzern 11-2, 52-74 (1932).

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